Enabling Technologies for the Wireless Internet

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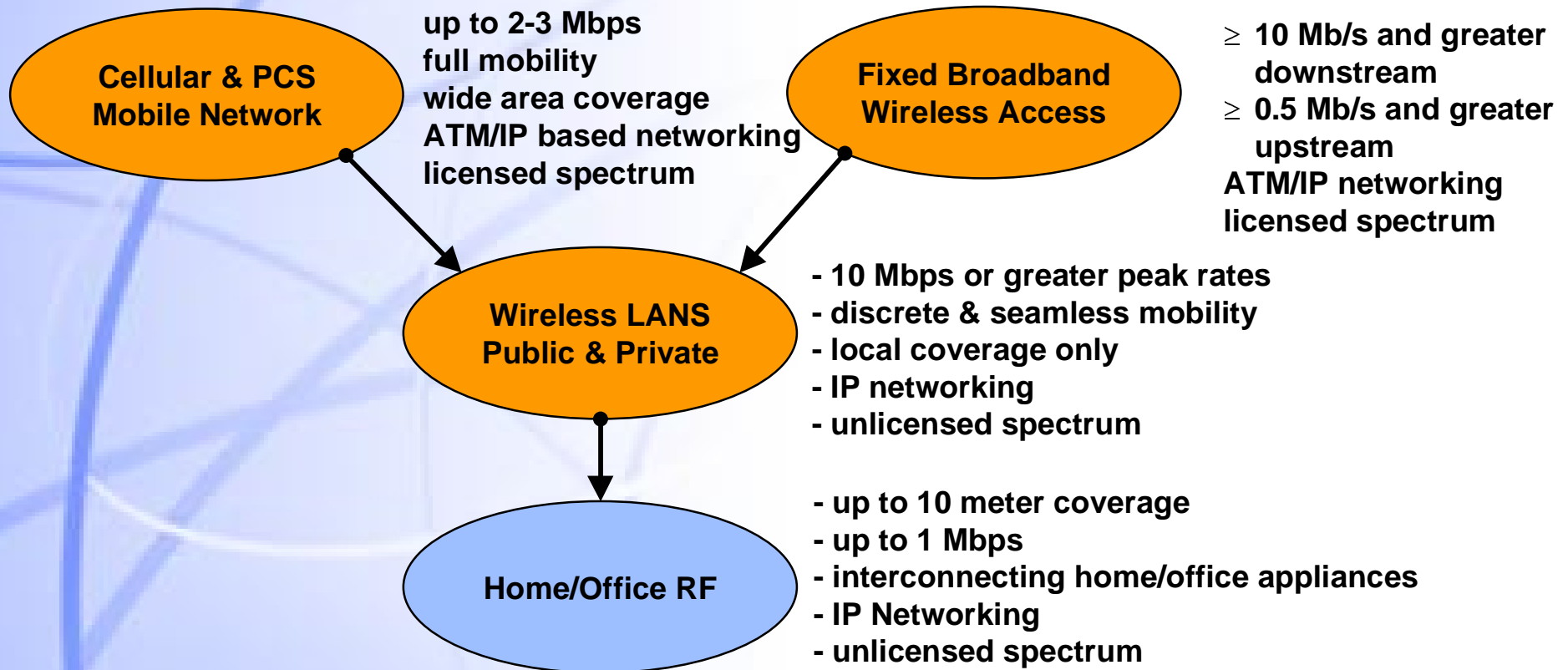
FCC OET Tutorial

November 30, 1999

Outline

- *Introduction*

- *Market Drivers*

- *Wireless Internet Networks*

- *Wireless Access Evolution*
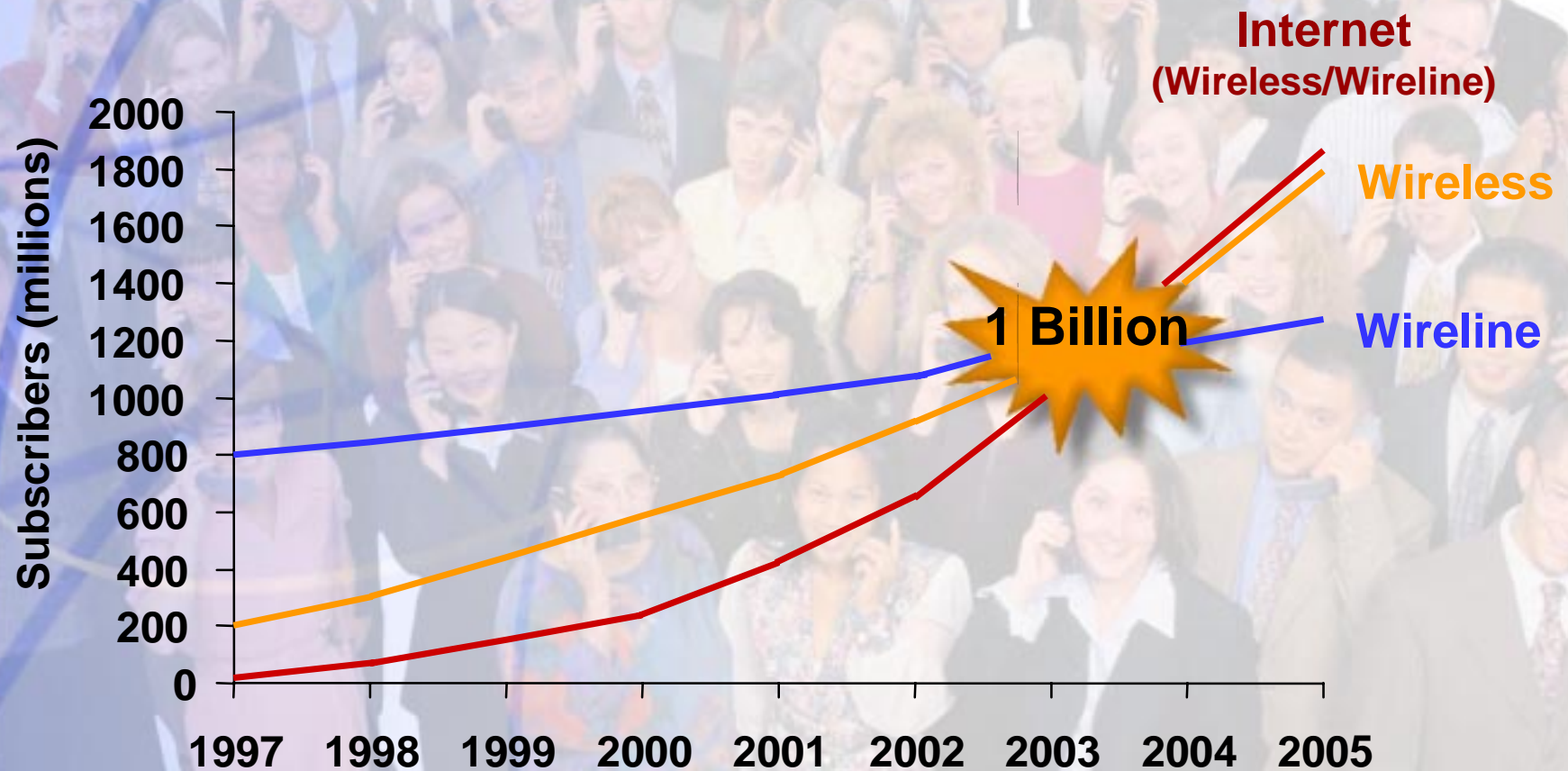
- *Enabling Technologies*

- *Summary*

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Introduction

Wireless Domains

Cellular & PCS Mobile Network

up to 2-3 Mbps
full mobility
wide area coverage
ATM/IP based networking
licensed spectrum

Fixed Broadband Wireless Access

$\geq$ **10 Mb/s and greater downstream**
$\geq$ **0.5 Mb/s and greater upstream**
ATM/IP networking
licensed spectrum

Wireless LANS Public & Private

- 10 Mbps or greater peak rates
- discrete & seamless mobility
- local coverage only
- IP networking
- unlicensed spectrum

Home/Office RF

- up to 10 meter coverage
- up to 1 Mbps
- interconnecting home/office appliances
- IP Networking
- unlicensed spectrum

Nortel wireless products and networks cover cellular & PCS mobile, fixed broadband, public and private Wireless LAN access
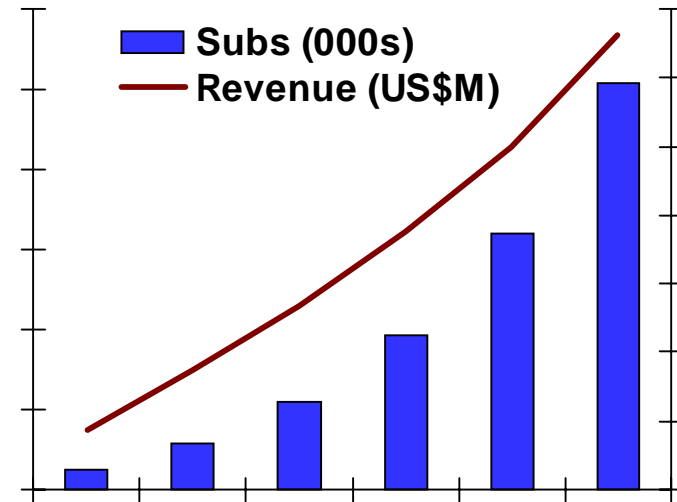
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Market Drivers

Internet Growth Fueled by Wireless

Internet
(Wireless/Wireline)

Wireless

1 Billion

Wireline

Subscribers (millions)

2000
1800
1600
1400
1200
1000
800
600
400
200
0

1997 1998 1999 2000 2001 2002 2003 2004 2005

Source: Nortel Networks

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Wireless Internet Forecast - U.S. A New Paradigm

- In 5 years:
  - **50 million wireless Internet subscribers**
  - **$6.6 B in Wireless Internet revenue (annually)**

Legend: Subs (000s) — Revenue (US$M)

- 75 percent of Wireless Internet revenue will be driven by wireless access to basic Internet and intranet services

- Additional revenue from access to premium content, enterprise information and communities of interest

Source: Nortel Networks / Yankee Group Study, August 1999

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Wireless Internet Networks

Next Generation Networks
The Challenges

- ## Bandwidth

  - The Internet is bandwidth intensive, but even 3G standards will support only up to 384 kbps, far short of the peak data rates and capacities Ethernet, cable or ADSL interfaces can offer

- ## Reliability

  - Radio links are notoriously unreliable and error-prone

- ## Protocols

  - TCP/IP-aware air interface design

  - Quality of Service (QoS) control according to service type

Next Generation Networks
The Challenges - cont'd

- Mobility

  - The Internet is not designed to handle terminals which quickly change their points of attachment

- Terminals

  - The network must handle wireless phones and PDAs with limited screen space as well as laptop PCs with wireless modems
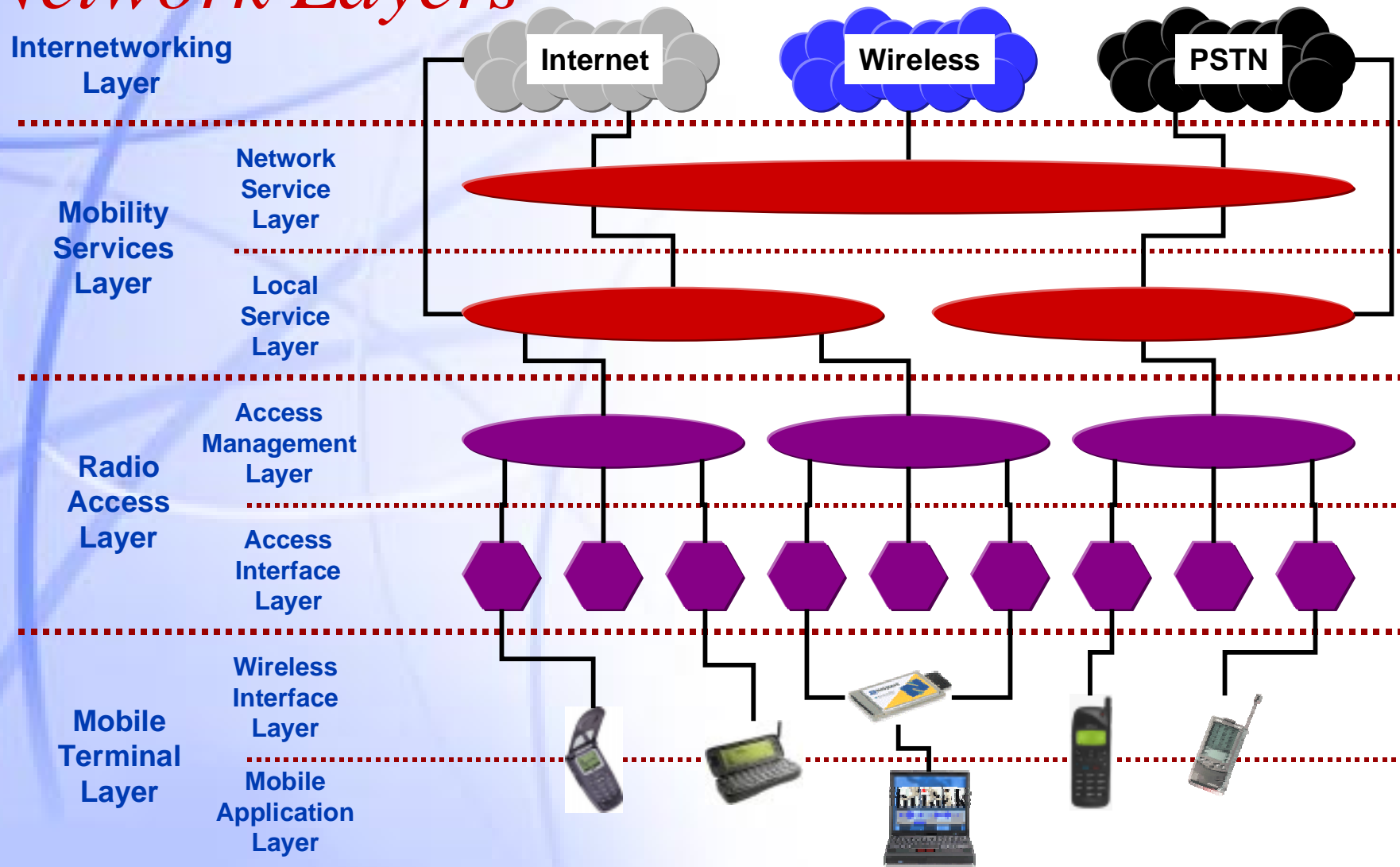
Next Generation Networks
Network Architecture

- **The Next Generation Network must integrate wireless access, user mobility and Internet technology into a seamless whole**

  – Exploit and extend existing IETF protocols and recommendations (RADIUS, IPSec, SIGTRAN, MEGACO, MMUSIC, etc.)

  – Design the components so that the network is cost-effective, scalable and carrier-grade

  – Make it transport, access and application agnostic:

    – The network should run over any transport technology (ATM, Ethernet, etc.)

    – Wireless specifics should be hidden in the Radio Access Network (RAN) or behind wireless gateways

    – Terminals should be able to interact with any IP-based telephony or data service with the appropriate client software

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Wireless Internet Networks
Network Layers

Internetworking Layer

Internet

Wireless

PSTN

Mobility Services Layer

Network Service Layer

Local Service Layer

Radio Access Layer

Access Management Layer

Access Interface Layer

Mobile Terminal Layer

Wireless Interface Layer

Mobile Application Layer

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Wireless Access Evolution

Nortel Networks Air Interface Evolution Path

2001

2000

1999

Multimedia

- IMT-2000
- **144 kbps to > 2 Mbps**

Higher Speed Packet Data

- GPRS and EDGE
- 1XRTT (CDMA)
- **64 - 384 kbps**

2G Low Speed Packet and Circuit Data

- Circuit Data (GSM / CDMA / TDMA)
- Cellular Digital Packet Data (CDPD)
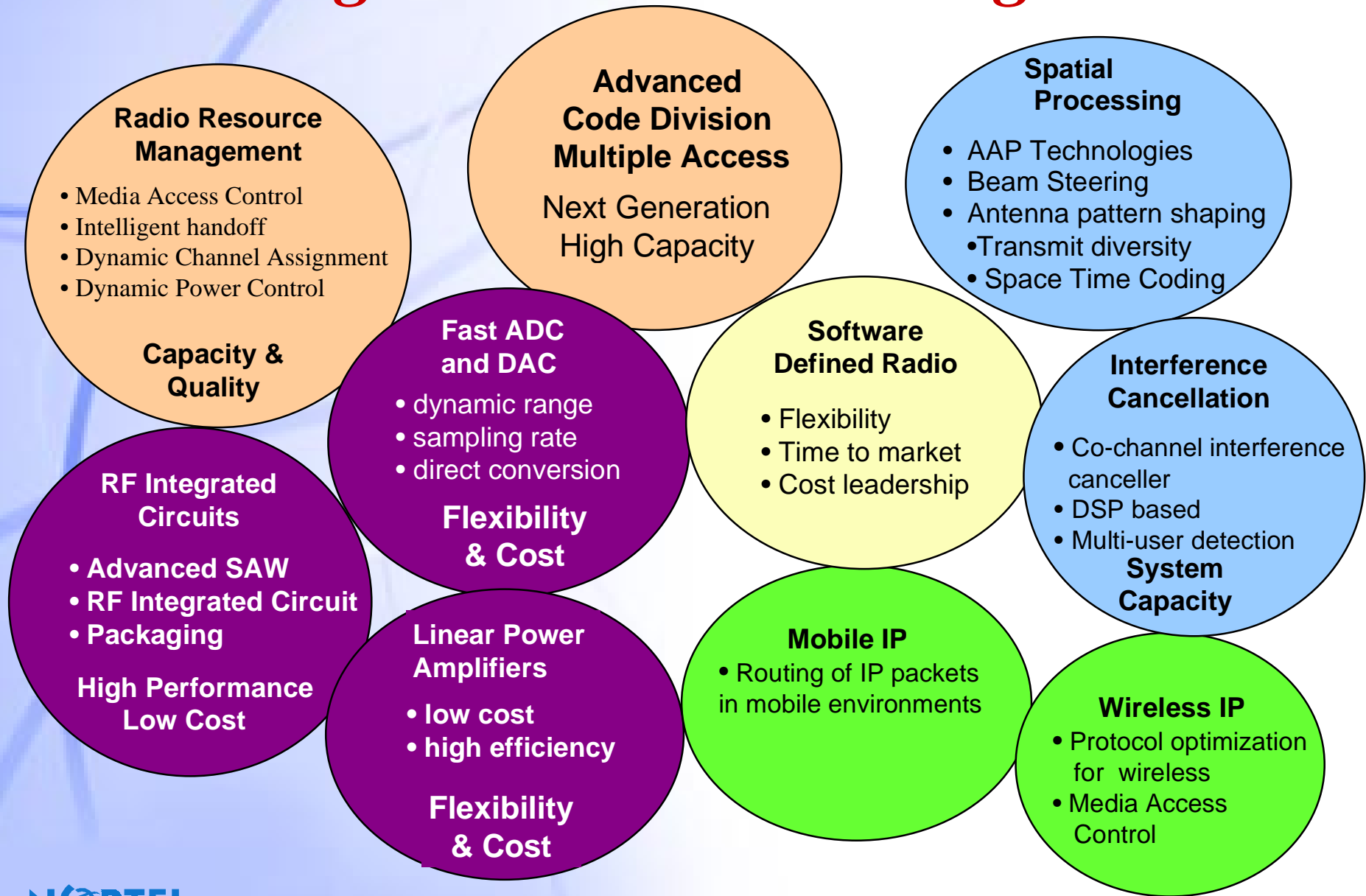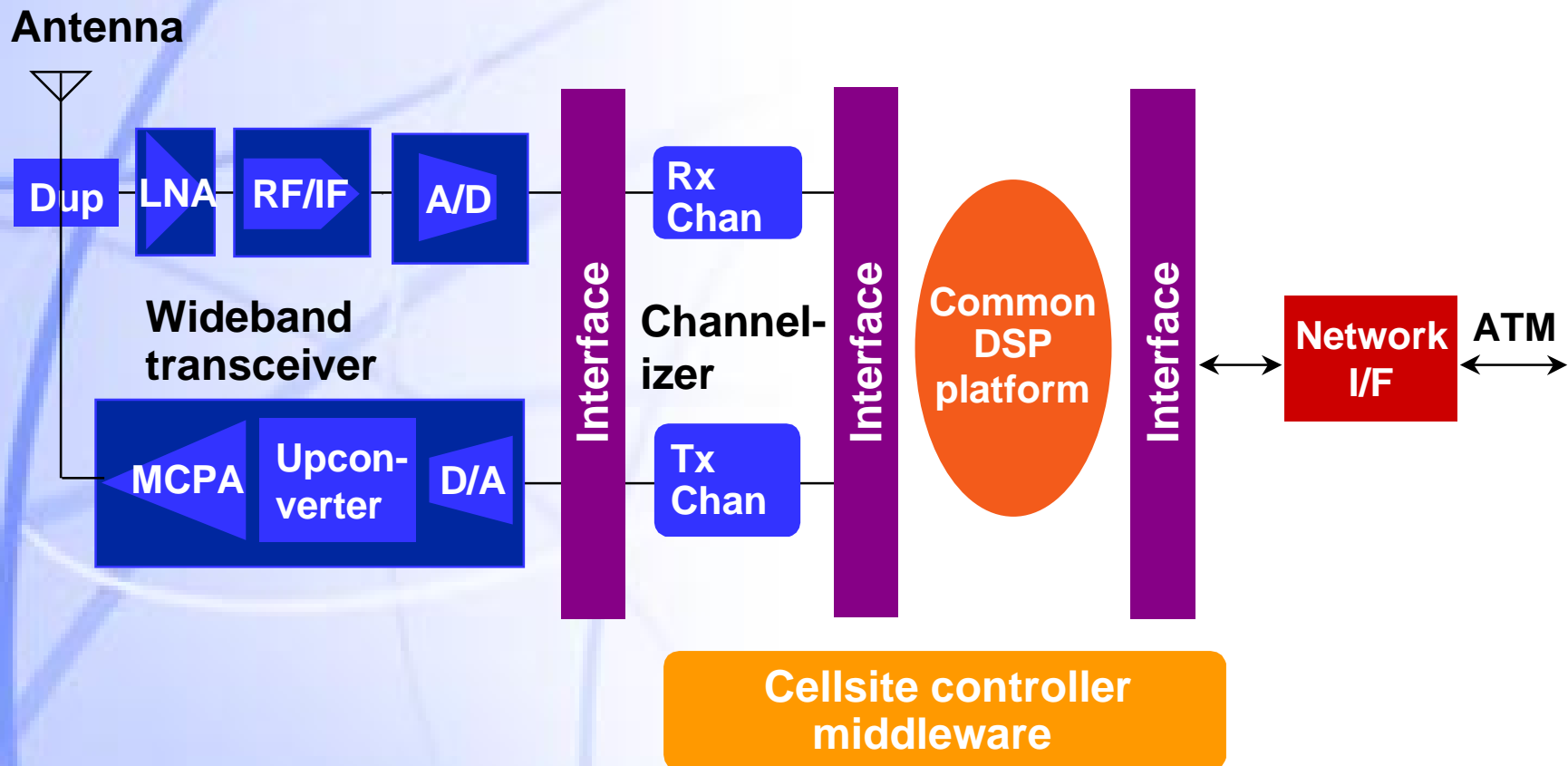- 2 - Way short messaging (SMS)
- **9.6 - 19.2 kbps**

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Enabling Technologies

Enabling Wireless Technologies

Radio Resource Management

• Media Access Control
• Intelligent handoff
• Dynamic Channel Assignment
• Dynamic Power Control

Capacity & Quality

Advanced Code Division Multiple Access

Next Generation High Capacity

Spatial Processing

• AAP Technologies
• Beam Steering
• Antenna pattern shaping
•Transmit diversity
• Space Time Coding

Fast ADC and DAC

• dynamic range
• sampling rate
• direct conversion

Flexibility & Cost

Software Defined Radio

• Flexibility
• Time to market
• Cost leadership

Interference Cancellation

• Co-channel interference canceller
• DSP based
• Multi-user detection

System Capacity

RF Integrated Circuits

• Advanced SAW
• RF Integrated Circuit
• Packaging

High Performance Low Cost

Linear Power Amplifiers

• low cost
• high efficiency

Flexibility & Cost

Mobile IP

• Routing of IP packets in mobile environments

Wireless IP

• Protocol optimization for wireless
• Media Access Control

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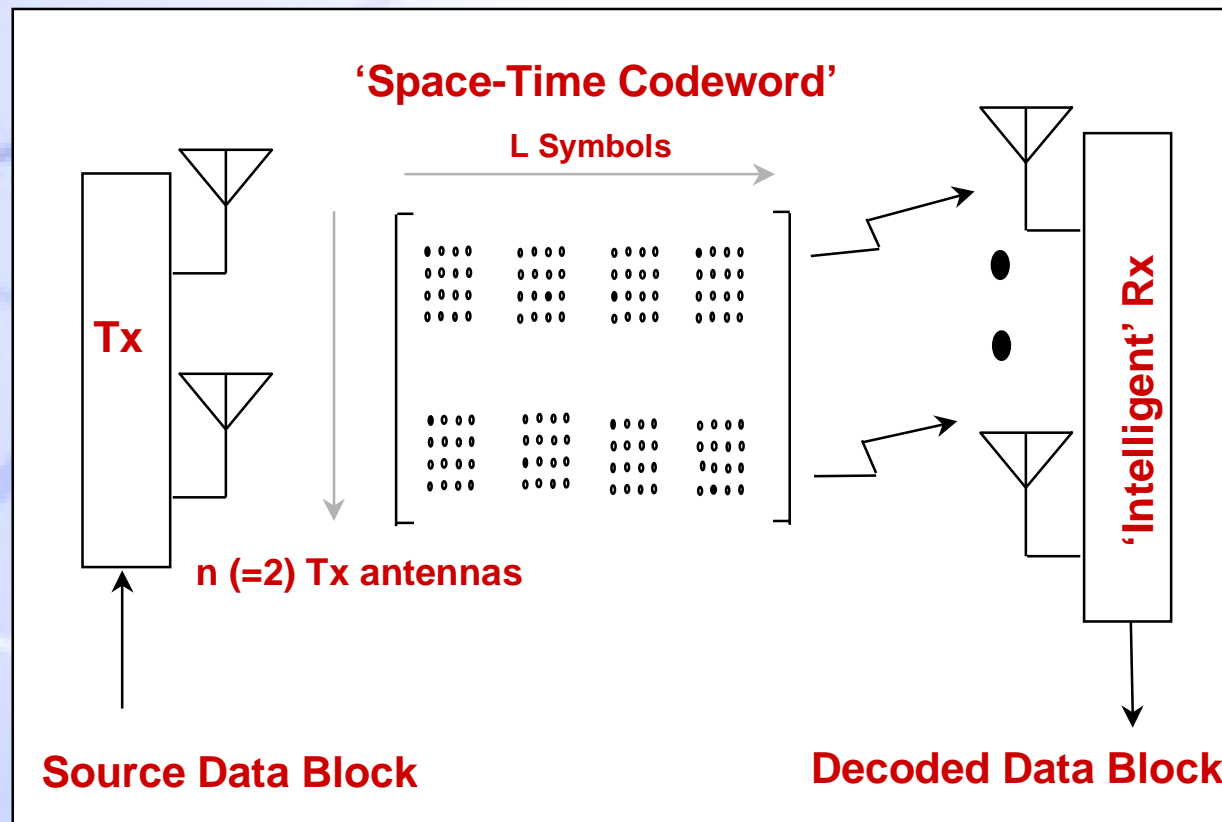
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Software-Defined Radio

- **Common technology for multiple radio platforms**
- **Speed to market**
- **Cost reductions**

Adaptive Antennas & Space-Time Coding

'Space-Time Codeword'

L Symbols

Tx

n (=2) Tx antennas

'Intelligent' Rx
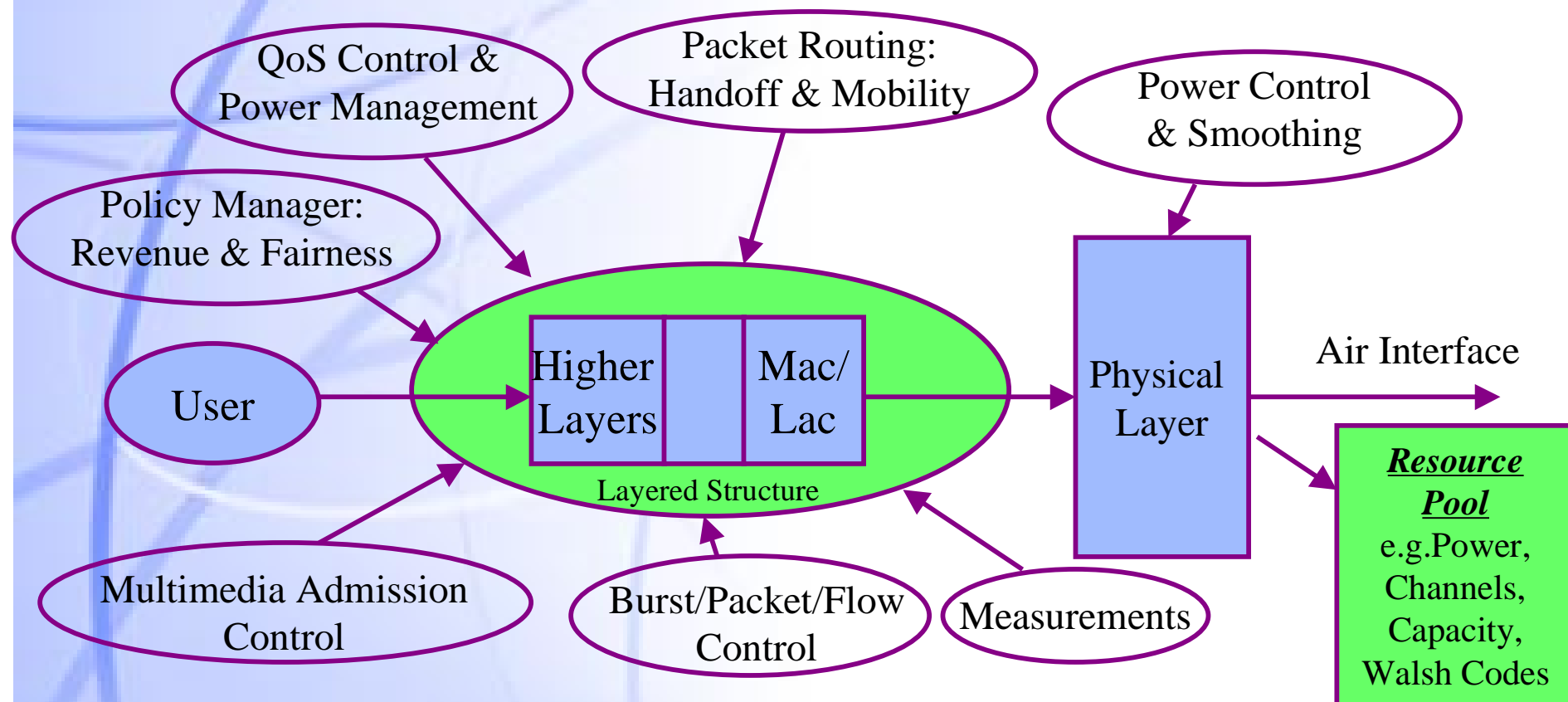
Source Data Block

Decoded Data Block

- **System capacity & performance improvements**

IP Mobility Enabling Technologies

- **Network/Access Independent Security & Authentication**
  - IPSec, Digital Signatures

  - KENA – Centralized Key Management
- **MIP extensions -> IP Mobility**
  - aljaved@nortelnetworks.com
  - real time location tracking
  - Real time address resolution

- **Horizontally Integrated Networks**
 - IETF

Radio Resource Management

Optimize Mapping of Physical Layer Resources to User Requirements

QoS Control & Power Management

Packet Routing: Handoff & Mobility

Power Control & Smoothing

Policy Manager: Revenue & Fairness

User

Higher Layers | Mac/ Lac

Layered Structure

Physical Layer

Air Interface

Multimedia Admission Control

Burst/Packet/Flow Control

Measurements

Resource Pool
e.g. Power, Channels, Capacity, Walsh Codes

- Balance subscriber expectations for maximum service quality with operator expectations to maximise revenue
- Match resource allocation and usage to IP flow requirements
- Provide QoS levels according to service requirements

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Radio Access Network
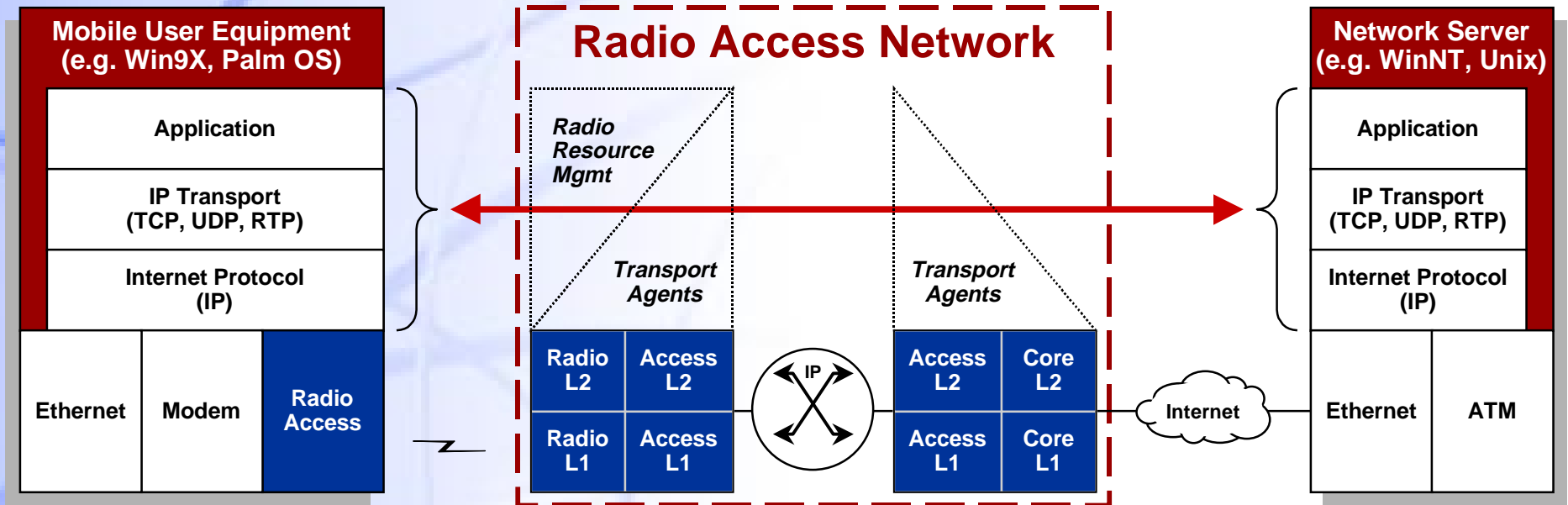
Radio-Optimized IP Networking
- Transparent to TCP/IP protocols
- Enables deployment of IP-based consumer applications in next generation wireless systems
- Lower cost by reusing wireline IP network elements in wireless access network
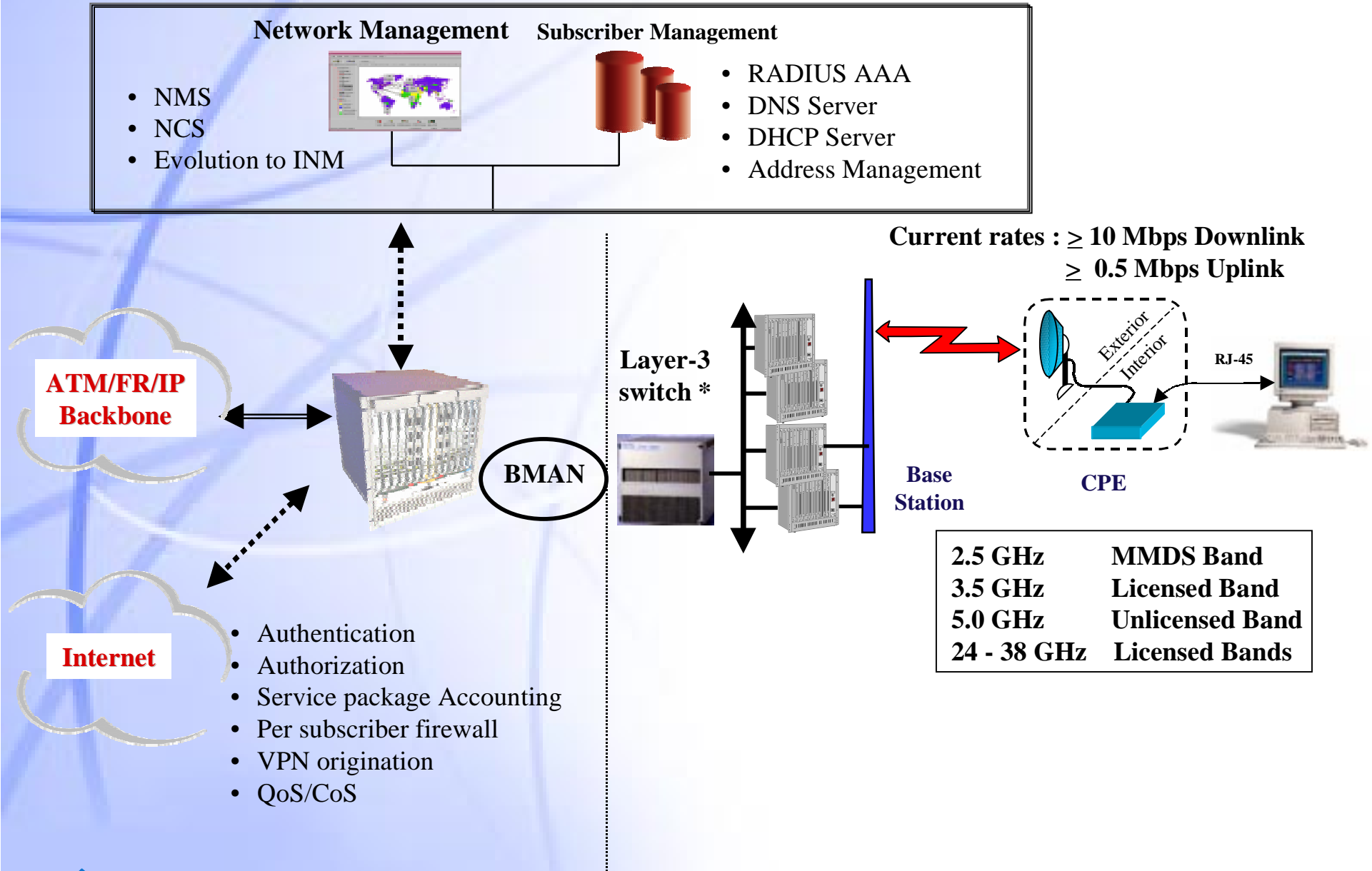
Technology System Impacts Over The Next 2 Years

- 3G will support data rates of 144 kbps, 384 kbps and 2.048 Mbps in vehicular, pedestrian and indoor environments, respectively

- Provides wireline quality voice, packet data, stream data and multimedia services

- Expect 2-4 fold capacity increase for voice and corresponding cost reductions, as well as better transmission performance

- Provides efficient design for packet data

  - Use of a combination of dedicated and shared channels for efficient spectrum utilization

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Evolution of 3G Mobile Systems

- **Expect 5 - 10 fold increase in peak data rates (to 10 Mbps for nomadic subscribers) and capacity for data services via**

    ⇨ **more advanced system concepts**

    ⇨ **more aggressive use of advanced antenna and space time processing and signal processing such as Multi-User Detection**

- **Higher speed Internet access will lead to both improved services and a wider range of new multimedia services**

- **Costs will be reduced due to continued application of Moore's Law and the development of the integrated CMOS radio for subscriber terminals**

Fixed Wireless Internet Access

Network Management   **Subscriber Management**

- NMS
- NCS
- Evolution to INM

- RADIUS AAA
- DNS Server
- DHCP Server
- Address Management

Current rates : ≥ 10 Mbps Downlink
≥ 0.5 Mbps Uplink

ATM/FR/IP Backbone

Layer-3 switch *

BMAN

Exterior
Interior

RJ-45

Base Station

CPE

Internet

- Authentication
- Authorization
- Service package Accounting
- Per subscriber firewall
- VPN origination
- QoS/CoS

2.5 GHz	MMDS Band
3.5 GHz	Licensed Band
5.0 GHz	Unlicensed Band
24 - 38 GHz	Licensed Bands

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Summary

- **Fusion of Wireless and the Internet is well underway. Current mobile systems are providing narrowband Internet access**
- **The wireless industry is developing harmonized standards for Internet access and targeting higher rate, high efficiency product deployments in the 2000-2002 timeframe**
- **These standards exploit new technologies to provide for growth and evolution to extend the full potential of the Internet to the wireless user**
- **These technologies will lead to improved performance, capacity and lower cost**

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